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by

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Costs of Improving Recruit Aptitudes: A Joint Product Approach

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**COSTS OF IMPROVING RECRUIT APTITUDES:
A JOINT PRODUCT APPROACH**

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**1 October 1990
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ABSTRACT

This paper presents and applies a methodology for estimating the cost of recruiting individuals with alternative distributions of Armed Forces Qualification Test (AFQT) scores. The methodology takes account of the key institutional features of the recruiting process, including recruiter time allocation and procedural guidelines. The method is used to estimate the costs of different recruit-aptitude distributions, using data on applicants and accessions for all of the services.

INTRODUCTION

Military enlistments are described by both quantity and quality. Quality is traditionally measured by scores on the Armed Forces Qualification Test (AFQT), a measure of aptitude, and by whether the recruit is a high school graduate. Better quality recruits are more expensive to recruit, but they are also less costly to train, more proficient once they are trained, and less likely to be discharged during the initial enlistment. To arrive at a quantitative basis for decision-making, the higher costs of recruiting (and maintaining) higher quality recruits could, in principle, be balanced against the advantages of lower turnover costs and greater productivity.

This paper presents and applies a methodology for estimating the recruiting costs of forces of different quality. The analysis focuses on one dimension of quality, aptitude, as measured by AFQT scores. The methodology is intended to take account of the key institutional features of the recruiting process, such as the way recruiters allocate time and the detailed guidelines under which they operate. The method is then used to estimate the costs of different aptitude mixes, using data on applicants and accessions for all of the services.

A model such as this could be used to do the following:

- Estimate the costs of improving the AFQT mix.
- Estimate the worsening in the AFQT mix that would accompany cuts in the recruiting budget.
- Cost out alternative accession cohorts involving both different aptitude mixes and accession levels (such as a decline in accession levels combined with an improvement in the aptitude distribution).
- Study cost-effective tradeoffs between accession and retention.

A CAVEAT

Because military readiness or productivity is difficult to measure, questions about the benefits of recruit quality are among the most difficult in military manpower research. Beyond the difficulties of measuring the benefits of better recruit quality, there remain difficult questions concerning the costs. One such problem is the unobservability of key magnitudes such as the level and type of effort exerted by recruiters. Thus, analyses of both benefits and costs are subject to substantial potential error. For this reason, this paper presents ranges of estimated costs and benefits.

RECRUIT QUALITY IN THE 1980s

The characteristics of individuals recruited by the military services are important predictors of their success in service. In addition, the desired quality mix of recruits is the most important determinant of required recruiting costs. The most successful recruits hold a regular high school diploma and score at or above the 50th percentile on the AFQT. Such recruits have demonstrated both adaptability and trainability in all the services.

The interest in recruit trainability led to development of standard categories of recruits, grouped by percentile ranges on the AFQT (table 1). This paper focuses on the costs of different distributions of recruits among these categories.

Table 1. AFQT categories

AFQT category	Percentile range
I	93+
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

Recruits scoring in categories I-IIIB of the AFQT are generally not screened out by recruit quality objectives. Those without high school diplomas, or scoring below the 30th percentile, may be screened out. Table 2 shows the historical percentages of DOD, Navy, and Marine Corps recruits with AFQT scores exceeding the 30th percentile (test score categories (TSC) I-III), and with high school diplomas. During the draft era, 1964 through 1973, 72 percent of all DOD recruits were high school diploma graduates (HSDGs) and 80 percent scored in AFQT categories I-III.

Table 2. Quality of non-prior-service enlisted accessions: percentage with high school diploma and scoring above 30th percentile on AFQT

Fiscal year	DOD		Navy		Marine Corps	
	HSDG	TSC I-III	HSDG	TSC I-III	HSDG	TSC I-III
1980	68	65	75	80	78	69
1981	81	79	76	86	80	84
1982	86	85	79	88	85	89
1983	91	90	91	90	92	91
1984	93	91	93	90	95	93
1985	93	93	89	90	97	96
1986	92	96	85	90	98	99+

NOTE: The youth population is estimated to consist of 75 percent HSDGs and 69 percent AFQT categories I-III.

SOURCE: OASD (FM&P). *DOD Appropriations for 1988, Hearings Before the Subcommittee on the DOD.*

Both the Navy and Marine Corps increased the proportion of HSDGs significantly during the 1980s, especially in the favorable recruiting climate of 1982 through 1984. Since then, the Marine Corps has practically stopped recruiting people in the low-test-score category (category IV) and without high school diplomas. How recruiters achieve such changes in the recruit quality mix provides the foundation for estimating the costs of improving recruit quality.

RELATED RESEARCH

Several recent studies of recruiting and recruit supply acknowledge and incorporate the effects of demand influences and production tradeoffs on observed enlistments (references [1, 2, 3]). Among these, references [1, 2] are the most closely related to this research. In fact, reference [1] has served as the basis for much additional research on the effects of enlistment incentives and advertising (references [4, 5]). The following quote from reference [1] illustrates how recruiters can affect the quality of accessions:

...recruiters do not passively process enlistments; rather, they have considerable discretion over the allocation of resources, the most important of which is their own time. Recruiters can influence both the quantity and quality of enlistments by engaging in different types of activities—for example, high school “career day” programs, Key Club meetings, and Eagle Scout gatherings. In contrast, he or she could rely more on walk-ins or youth counseling referrals. Also, the recruiter can invest time by screening and selecting candidates with the highest probability of being in the high-quality category.

The analysis in reference [1] that accompanies this crucial insight is based on a production tradeoff curve showing that the potential to produce low-quality enlistments declines as high-quality enlistments increase, and vice versa. Figure 1 shows a representative diagram. It has the following properties:

- At point A on the diagram, recruiters are producing fewer high- and low-quality recruits than they could with the same level of effort that produces the output mixes B and C. Points like A represent relatively inefficient production, other things being equal.
- Production points like B and C on the tradeoff curve represent different allocations of effort between high- and low-quality recruits using the best available recruiting techniques.
- The only way to increase the number of both high- and low-quality recruits starting from points on the tradeoff curve is to increase total recruiting effort.
- Changes in recruiting resources other than recruiters, such as advertising and enlistment incentives, as well as changes in civilian employment opportunities, shift the position of the tradeoff curve. For example, a decline in the civilian unemployment rate would be associated with an inward shift of the tradeoff curve. For the same level of effort, recruiters would become less productive as civilian job opportunities improved.

Figure 1 here

A production tradeoff curve shows the possibilities, but does not identify a particular outcome. Actual recruiter effort and the allocation of effort determine, in part, the point of chosen production. To complete the analysis, reference [1] assumes that recruiters maximize a utility function by choosing the number of high-quality and total enlistments subject to the constraint of an implicitly defined production tradeoff curve. Except for a general discussion of the production tradeoff in figure 1, and the above quotation, reference [1] provides no analysis of the recruiter time allocations needed to produce different recruit quality mixes. Econometric estimation of recruit supply in reference [1], however, shows that a 10-percent reduction in low-quality enlistments (HSDGs with AFQT scores below the 50th percentile—category IIIB) would result from roughly a 3-percent increase in high-quality enlistments, other things being equal. This estimate implies a tradeoff of between three and four low-quality enlistments for one high-quality enlistment. It also implies that, if total accessions are held fixed, shifting to higher quality requires more recruiting resources. If the definition of low quality is changed to mean non-HSDG, reference [1] estimates that about six non-HSDG enlistments must be forgone to get an additional high-quality enlistee (HSDG with AFQT score above the 50th percentile).

Reference [2] addresses the production tradeoff of HSDGs for non-HSDGs faced by Marine Corps recruiters. In this reference [2], the relative costs of additional HSDGs (irrespective of AFQT category) are estimated by making explicit assumptions about the amount of time that Marine Corps recruiters spend processing non-HSDG recruits. Furthermore, the supply of non-HSDG recruits who require a fixed amount of processing time per recruit is assumed to be very large relative to the recent demand for such recruits (i.e., they are regarded as "demand-limited" and "free" in terms of recruiting resources). Recruiters are assumed to maximize utility—which is a function of HSDG enlistments and total enlistments, subject to a fixed level of total recruiting effort—by choosing the allocation of recruiting effort to HSDGs and non-HSDGs. Total recruiter effort, however, is endogenous and can be expected to change with supply and demand conditions. Changes in recruit supply will generally affect the allocation of effort and production between HSDGs and non-HSDGs. For example, as relative military pay increased during the 1980s, Marine Corps recruiters spent less time processing low-AFQT (category IV) HSDGs. Although shifting effort complicates interpretation of the results, the study estimates that, in the range of recent accession levels and supply conditions, Marine Corps recruiters spend at least ten times as much time enlisting an additional I-III A HSDG as they do enlisting an additional walk-in non-HSDG.

These analyses of recruiting tradeoffs each consider only two quality categories. With available data, analyzing tradeoffs between more detailed quality breakdowns requires diverging from the econometric methodology of these studies. This study investigates an alternative methodology: a process or linear programming model of recruiting. Where possible, the parameters of this model are checked against those in the econometric studies. One advantage of the process methodology is that it not only represents the tradeoffs among recruits in the different AFQT categories but also identifies how to move from one mix to another.

RECRUITER TIME ALLOCATION AND THE STAGES OF PRODUCTION

The point of departure for the methodology is recruiting technique and the allocation of recruiter time. The description of technology and time allocation is based on Navy recruiter training and practice, but it is similar for all the services. There are two major components, or stages, of recruiting activity: prospecting for recruits (stage I) and processing of recruits (stage II).

Chapter 5 of reference [6] describes the prospecting activities that Navy recruiters are taught and expected to use. According to the introduction to that chapter, a recruiter's "success in prospecting is measured by the number of interviews . . . that result." The processing stage then begins with the applicant interview, which is typically generated in the previous prospecting stage. Recruit candidate interviews that are not the result of prospecting activity are called walk-ins. A recruiter's time-allocation problem can be framed in terms of these two types of activities. Figure 2 illustrates a recruiter's choices. For simplicity, only four production activities are shown, and they approximate actual choices between activities that recruiters must make. In addition, recruiters have a residual of "personal time" that influences their quality of life.

Figure 2 here

The two prospecting activities shown in figure 2 are school prospecting and work-force prospecting. Depending on the degree to which recruiters can successfully target their prospecting activity by tested aptitude, they have some control over the quality of the resulting prospects (interviews/applicants). The recruit processing stage is, however, the point at which recruiters exercise much greater leverage over the recruit quality mix. To demonstrate the differences between the processes as they relate to recruit quality, the characteristics of each activity are discussed, using reference [6] as a guide.

School Prospecting

Over the past 15 years, a standard set of procedures has been developed for the prospecting of high school students. The telephone is the basic tool for targeting these students. Recruiters obtain lists of students from the schools wherever possible, and use other sources to identify students where lists are not available. Students are then called to determine their interest in a Navy enlistment. However, without additional information on each student, which is only obtainable through other school-related prospecting activities (such as presentations at career days and interviews with school guidance counselors), the recruiters cannot even approximately target their telephone prospecting of high school students to different AFQT categories.

Recruiters are strongly encouraged to establish working relationships with school officials, guidance counselors, and teachers and to get involved in appropriate school activities. Through these personal contacts with "centers of influence" within the schools and with the students themselves, recruiters can attempt to target higher quality prospects.

But for several reasons, it may be impractical, given current and foreseeable incentives, for recruiters to be very selective with regard to anticipated AFQT scores during the prospecting stage (stage I). First, there may not be many members of school organizations who are selected on the basis of grades or measured aptitude. The smaller the pool of individuals in such self-selected organizations, the more difficult it is to achieve a given recruiting objective when focusing prospecting effort on such organizations. In addition, these individuals are likely to have strong intentions to attend college. It is also likely that recruiters will seek the referrals and potential "insurance" enlistments that interviews with lower-aptitude prospects may provide. Finally, not all high school centers of influence (such as counselors) are eager to cooperate with recruiters.

Work-Force Prospecting

General telephone prospecting is not widely used for the work-force market, in part because of the difficulty of targeting prospects. In the work force, personally developed contacts and advertising leads are the major sources of prospects. Recruiters obtain these contacts through Navy-related organizations and visits to establishments patronized by young people. In this process, recruiters try to select activities, organizations, and establishments in which relatively large proportions of high-quality prospects are likely to be found. The work-force market, however, probably contains a higher percentage of non-HSDGs and of lower AFQT category prospects than the high school/college market. Unless work-force prospecting can be targeted to high-quality subpopulations, prospecting in the work force is likely to yield a lower percentage of high-quality applicants than the same effort would yield in the high school or college population. On the other hand, the total number of prospects per unit of time prospecting in the work-force market probably will be higher than in the student market.

Figure 3 illustrates hypothetical prospecting (stage I) relationships. The two prospecting activities are shown by the lines labeled *school* and *work force*. (In the mathematical model, the origin is shifted to point *W*, representing the number of walk-in interviews or applications of high- and low-quality candidates.) The point *D* represents the numbers of high- and low-quality applicants that would be obtained from, say, one year of school prospecting, and point *E* represents the results of a similar effort in work-force prospecting. The number of applicants obtained will depend on the skill of the recruiter, local attitudes toward the military, and civilian employment opportunities.

Figure 3 here

The tradeoff curve, *CDEF*, represents the output of applicants obtainable with one year of prospecting activity. The segments *CD* and *EF* are relevant only if the recruiter turns down interviews with low- and high-quality prospects. If the recruiter does not turn down potential applicants, only the *DE* segment of the tradeoff curve is obtainable (any point in the area *ODE* is feasible in this circumstance).

The recruiter can achieve different quality mixes of interviews by varying the proportion of time spent prospecting in the two markets. In practice, it appears that recruiters focus on school prospecting during October through January and late spring. Late winter, early spring, and summers are usually associated with work-force prospecting. In better recruiting markets, there is a tendency to spend more time in school prospecting. Recruiting commanders typically direct the timing of school and work-force prospecting. As figure 3 makes clear, recruiter prospecting effort is not allocated directly to prospects of different quality. For each type of prospecting, school and work force, a given amount of effort will yield both high- and low-quality prospects. The linear process model assumes that the ratio of high-quality prospects to low-quality prospects cannot be modified except by shifting prospecting effort between the school and work-force markets.

Processing Activities

The processing of prospects includes all of the activities that recruiters must complete to convert an interview with a prospect into an enlistment contract. The interview itself tests the ability of the recruiter to demonstrate to the individual that the military service is the best opportunity available. Once it is determined that a prospect wishes to complete an enlistment application and appears to be eligible for enlistment based on preliminary screening during the interview, the applicant is scheduled for an appointment with the Military Entrance Processing Station (MEPS). (The preliminary screening includes administration of an Enlistment Screening Test (EST) that is a reasonably good predictor of performance on the AFQT.) This phase includes a police check, reference check, birth verification, enlistment application, medical screening, aptitude testing, and classification or job placement. The recruiter is advised to "lead applicants by the hand until they are actually on their way to recruit training" (reference [6], p. 7-2).

The result of a MEPS appointment will be an enlistment contract if the prospect is qualified and willing to enlist. At any point in the process, the recruiter or job classifier (service guidance counselor) may terminate the process if the applicant does not meet the requirements of the service. In particular, once the applicant's AFQT is determined, the recruiter or classifier may stop processing the applicant if the score falls below a policy-determined cutoff point. At this point, however, the recruiter has invested a substantial amount of time in the overhead activities of prospecting and preliminary processing.

Figure 4 illustrates recruiters' control of the quality mix (for a given expenditure of time on processing). If more candidates are available, the curve can be shifted out by reallocating time from prospecting to processing.

Figure 4 here

The number of high-quality enlistments, H , is determined by the number of high-quality interviews obtained during the period, and the recruiter's skill and effort in converting interviews to enlistments. At H_0 , the recruiter is not processing any low-quality enlistments. L_0 is similarly the largest number of low-quality enlistments that could be obtained if only those enlistments are processed. By reallocating effort during the processing stage (e.g., by not completing the processing stage for low-quality prospects), the recruiter may obtain any desired mix of enlistments (such as J or K).

Monitoring Adherence to Standards

Until the latter part of FY 1989, the Navy used an activity analysis system to help monitor and direct recruiter effort. Although use of the system stopped in the summer of 1989 as a result of a management review, it undoubtedly affected Navy recruiter effort during the 1980s.

For example, prospecting standards for a recruiter were established by determining how many telephone calls and interviews would be required to obtain the recruiter's goal for enlistments. Using data on recent activity, it might be determined, say, that each accession requires two applicants, each applicant requires four interviews, and each interview requires 30 telephone calls. Appropriate activity levels are then determined as the number of desired accessions multiplied by each of these productivity factors. The approach used in this paper is similar in principle. The major difference is that there are productivity factors associated with different markets and aptitude categories, but not with subcomponents of the prospecting or processing activities (e.g., telephone calls).

During the period when the activity analysis system was used, Navy recruiters were taught how to record their prospecting and processing activities, including telephone calls, personal contacts, and interviews and subsequent processing. Supervisory recruiters used these data for analysis, evaluation, and planning. In particular, field supervisors planned activity levels for recruiters on the basis of recent experience with prospecting and interviewing success rates. Field supervisors used the data to help recruiters allocate their time and to focus training and development efforts.

Inspectors who visited recruiting stations also used the activity analysis data to gauge the performance of recruiters. When recruiters were not performing prescribed activity but were nevertheless achieving quotas, the consequences were not great. But when recruiters were not performing the prescribed activity and were not achieving the expected number or quality of enlistment contracts, the district and zone leadership was criticized. In some circumstances, this combination of events may have contributed to replacement of the accountable leadership. Thus, recruiters were expected to follow established procedures, especially if they were having trouble making goal.

Even though the Navy's formal activity analysis system has been disestablished, recruiting supervisors must now perform a similar evaluation by some other means. The expectations that supervisors hold about appropriate types and levels of activities are not likely to change, though they will presumably have less information to use.

Recruiter Incentives

Recruiters value the recognition they receive if they are successful. To be successful, they may give up personal time and post-recruiting career investments, such as preparation for advancement exams. In the process, they will respond to various measures used by their supervisors to gauge performance. Positive incentives based on production provide awards to recruiters who perform far above the norm, and negative incentives associated with low production are used to encourage at least a minimum performance level. Recruiters may earn awards through district or national competition systems. The most intensely studied of the Navy award programs was the Freeman Plan, described in chapter 8 of reference [6] and in reference [7].

Reference [1] analyzes an award system for Army recruiters that is similar to the Navy plan. The analysis assumes that recruiters attempt to maximize recruiting "income" that consists of points awarded for enlistments of various quality types. It does not consider the fact that recruiters are evaluated on aspects of performance other than production. There have been strong incentives to use standard prospecting methods and to carefully document levels of effort as a means of demonstrating performance and effort. Recruiters are better off, other things being equal, if they satisfy their supervisor's activity plan for the evaluation period. Following the activity plan is an objective in itself, not just a means of meeting goal.

IMPLICATIONS FOR ESTIMATING RECRUITING COSTS

The most important implication of the above description of processing and prospecting is that recruiters cannot allocate their recruiting time to individual categories of prospects. Thus, it is not possible to allocate costs to these categories. For example, it is not feasible to estimate the costs of recruiting enlistees in AFQT category I because these costs cannot be disentangled from those of recruiting other categories. What is feasible to estimate is the cost of recruiting enlistees in all the mental categories taken together, and how this cost responds to changes in the mix of different AFQT categories.

A second implication is that estimated costs depend on how many processes there are in recruiting. For example, if there are not just two prospecting activities (school and work-force), but a wider variety of activities with similar costs, and different ratios of high-quality prospects, it may not be inordinately expensive to shift the AFQT composition of the force. Furthermore, because each activity could be incorporated in recruiter training and practice, there would be a way of indicating to recruiters how to proceed.

On the other hand, if there were only one general prospecting activity, recruiter effort could not be targeted to specific AFQT categories. Because effort would be undifferentiated, the only way to shift the composition of enlistees toward a richer AFQT mix would be to obtain more applicants of all types by adding recruiters or other resources. Too many applicants in the lower AFQT categories would be obtained, and the lowest scoring would not successfully compete for the limited number of accession slots. This would be an expensive way to improve average aptitude scores, but without multiple activities to target recruiting effort effectively, it would be the only way available.

RECAP AND MODEL PREVIEW

Before presenting the mathematical description, it is worth summarizing the previous discussion of the recruiting process as in figure 5. The flow of recruits is tracked from top to bottom in the diagram. The prospecting stage begins in either the school or work market, with prospect interviews as an intermediate outcome. The interview process then yields applicants as the ultimate outcome of the prospecting stage. These applicants include individuals identified by their test score category. Recruits then enter the processing stage, where the test score category is verified, and other medical and moral qualifying data are obtained. The enlistment agreement between the service and the applicant and the start of active duty are the final events in the processing stage.

Figure 5 here

The mathematical model translates this flow of recruits into a nonlinear optimization problem that has the following structure. The objective is to minimize the cost of obtaining a specified distribution of recruits by AFQT category. The processes used to obtain recruits are specified as constraints on the minimization. Most of these processes are linear by assumption, though diminishing returns to recruiters are included. The choices that recruiters have are (1) how to allocate their prospecting time between the school and work markets, and (2) which applicants to process through to the point of accession.

Optimization is by means of forward solutions. Starting values are assumed for the fraction of prospecting time devoted to the school market and for the number of recruiter years devoted to prospecting applicants. (The starting value for the number of recruiter years spent processing applicants is chosen to be too small to satisfy the constraints.) These starting values are used to calculate the number of accessions in each category and the total number of recruiters, including those needed to process applicants. In the ensuing iterative search process, the number of recruiters is increased in small increments. For each number of recruiters, different fractions of prospecting time devoted to the school market are used to generate different distributions of accessions. The number of recruiters and the fraction of prospecting time in the school market are adjusted in this way until accession requirements are met at least cost.

Here is a more complete verbal description of the model and its solution. In the prospecting stage, recruiters face the first key choice: how to allocate their prospecting effort between the two markets. The school and work markets are assumed to differ in the distribution of potential applicants by AFQT category. Specifically, the school market is assumed to be richer in relatively high aptitude recruits, while the work market is more productive in terms of total applicants. Thus, one way to improve the AFQT distribution is to allocate a greater proportion of prospecting time to the school market, accepting fewer total applicants in exchange. A second category of applicants, who may come from either the school or work markets, require no prospecting time. They are called "walk-ins" and have an AFQT distribution estimated from historical data. Applicants, by AFQT category, result from prospecting effort in the school and work markets and from walk-ins.

The processing stage is modeled by a set of equations that transform the number of applicants by AFQT category into accessions by AFQT category. Historically, a certain percentage of applicants fail to become accessions because of medical problems or legal involvement, or because they choose not to enlist. In addition, recruiters choose not to process individuals who do not meet the

service's aptitude requirement. This choice is the second key decision that affects the AFQT distribution of accessions (the first decision being the split of effort between the work and school markets).

Requirements are expressed as a specified number (and percentage) of accessions from each aptitude category. The model begins with a relatively small number of recruiters and proportion of prospecting time in the school market. The number of applicants in each AFQT category is calculated for both school and work markets. Walk-in applicants are then added. Processing-stage attrition is subtracted from the total, and the result is compared to requirements by AFQT category. In the comparison, higher aptitude recruits are allowed to substitute for lower aptitude recruits. If the requirements are not met, the proportion of prospecting time in the school market is increased to try to meet the requirements without increasing the number of recruiters. If the accession requirements by category cannot be met in this way, the number of recruiters is increased by a small increment, and the search is repeated. (Once the constraints are met, different fractions of time in the school market are tried to ensure that a true optimum has been reached.) The smallest number of recruiters that achieves the desired distribution of recruits is added to the number needed to process walk-ins to obtain the solution in terms of the number of recruiters. Using historical data for DOD, this number of recruiters is associated with a total cost figure for the required AFQT distribution.

The following section gives the mathematical formulation of this two-stage, multi-process description of recruiting. Readers who wish to skip the mathematics can go directly to the results without loss of continuity.

A MODEL FOR ESTIMATING THE COST OF HIGHER-APTITUDE RECRUITS

This section describes a mathematical model for assessing the relative costs of recruiting different mixes of AFQT scores. Costs are estimated initially as the number of necessary recruiters, then converted to dollar estimates. The number of recruiters is calculated as the smallest number satisfying a series of equations and constraints, which are described below.

The first two equations of the model describe yields of applicants per year of prospecting activity in the school market and work-force market.

$$AP_s = s * CA_s \quad (1)$$

$$AP_w = (1 - s)CA_w \quad (2)$$

where s is the fraction of prospecting time spent in the school market. The numbers CA_s and CA_w are the total number of applicants that a recruiter would obtain if all effort were devoted to school prospecting or work-force prospecting, respectively.

It is postulated that the distribution of applicants by AFQT category differs between applicants from the school market and applicants from the work-force market. The fractions a_{si} and a_{wi} represent the distribution of applicants across the AFQT categories (which are indexed by i). For example, a_{si} is the fraction of applicants in the school market who are in AFQT category i . The total number of applicants per recruiter in each AFQT category i is given by

$$AP_i = a_{si} \cdot AP_s + a_{wi} \cdot AP_w \quad (3)$$

Equation 4 converts applicants in AFQT group i from a value per recruiter (AP_i) to a total number of applicants across all recruiters, excluding walk-ins. Two adjustments will be made in arriving at this total. First, the number of recruiters is an adjusted number to take account of any diminishing effectiveness of adding more recruiters. Second, a parameter (w_i) is introduced to reflect which of the new applicants are walk-ins and which have been actively prospected. The interpretation of a value of $w_i = 0.25$ is that 25 percent of all recruits are walk-ins. With these conventions,

$$TAPV_i = AP_i(RE_i)(1 - w_i) \quad (4)$$

where

RE_i = effective number of recruiters

$TAPV_i$ = number of applicants who are not walk-ins.

Equation 5 describes applicants who are walk-ins. The number is the walk-in parameter (w_i) multiplied by the number of applicants in the base case. The base case refers to the observed 1987 number of recruiters (about 15,000) and the observed number of accessions (about 215,000). When the model is run to generate these base-case values, the number of applicants in category i is labeled TAP_{0i} . Walk-in applicants are $w_i \cdot 100$ percent of these applicants.

$$TAPW_i = TAP_{0i}(w_i) \quad (5)$$

Equation 6 combines applicants that are variable with respect to recruiting effort and applicants that are walk-ins to form total applicants:

$$TAP_i = TAPV_i + TAPW_i \quad (6)$$

Not all applicants are converted to accessions. There are two sets of parameters describing this conversion—the first set representing factors that are primarily outside the control of recruiters and the second set representing recruit screening based on aptitude.

The first set of parameters covers all the factors that have historically been associated with applicant attrition. They include the effect of disqualification on medical, moral, or mental criteria, and the decision of a qualified applicant whether to follow through with the enlistment. Historical experience provides a set of ratios (sel_i), one for each AFQT category, that are defined as the number of accessions in category i divided by the number of applicants in category i . (To some extent this will be an imperfect proxy for factors outside the control of recruiters since it may also pick up screening based on aptitude.) The number of accessions in each category is given by

$$TAC_i = sel_i * TAP_i \quad (7)$$

Some applicants have been denied enlistment because of low AFQT scores. It is assumed that applicants in AFQT categories I through IIIB are not disqualified because of measured aptitude. (This assumption does not reflect the behavior of the Air Force. Recently, some category IIIB applicants have been screened out of the Air Force, but they may have enlisted in another service.) Some category IV applicants, however, have been screened out by recruiters prior to the application stage, so sel_4 will already include the effect of some recruit screening.

The second set of parameters (scr_i) relates accessions and applicants. These parameters represent policy (applicant screening based on aptitude). The screening parameters specify the fraction of applicants in category i that are accepted for enlistment. The model allows one-for-one substitution from higher-quality accessions. In applying the model, the screening parameters are derived by specifying the required mix of accessions and then working back to the screening parameters. If any of the screening parameters exceed unity, the solution of the equations is disallowed, and another try must be made with more recruiters or a different mix between the school and work market.

Equation 8 specifies DOD-wide minimum acceptable requirements by AFQT category ($TRAC_i$), which are the quantities that the model is intended to cost out. Total requirements are specified in terms of fractional requirements (f_i), the required fraction of accessions in a particular AFQT group i .

$$TRAC_i = f_i[ACCSS] \quad (8)$$

where $ACCSS$ represents total required accessions, totaled across all categories.

Thus far, no account has been taken of any diminishing returns to the addition of more recruiters. For example, an addition of 1 percent more recruiters may bring in only 0.5 percent more accessions. The first step in incorporating diminishing returns is to define a measure of the number of recruiters relative to a current (or historic) baseline.

$$Rel = \frac{R}{R_0} \quad (9)$$

where

R = number of recruiters

R_0 = baseline number of recruiters

Rel = relative number of recruiters.

For this paper, R_0 is the number of recruiters necessary to generate a baseline distribution of AFQT scores that is similar to recent distributions. Details on this and other distributions are presented later.

Equation 10 defines the effective number of recruiters, taking account of the role of diminishing returns:

$$Re_i = R_0[Rel]^{\alpha_i} \quad (10)$$

where

RE_i = effective number of recruiters

R_0 = base number of recruiters

Rel = relative number of recruiters.

The parameter α_i is the elasticity of accessions in AFQT group i with respect to the number of recruiters. For example, if a 1-percent increase in the number of recruiters led to a 0.5-percent increase in accessions in group i , the elasticity would be 0.5.

Equations 1 through 10 determine the number of available accessions in a particular AFQT group and the number of accessions required. TAC_i is the number of accessions available in the group, and $TRAC_i$ is the required number. If the ratio of TAC_i to $TRAC_i$ is less than 1, this ratio represents the fraction of the available enlistments that need to be retained. The remainder can be screened out.

So far, the ratio does not take account of the possibility of substitution among different AFQT groups. The assumption made here is that accessions in groups with higher AFQT scores can substitute for groups with lower AFQT scores. For example, an accession in group II could substitute for an accession in group IIIA, but not vice versa. To represent this substitution, the ratio of available to required accessions is defined using cumulative totals.

$$SCR_i = \frac{\sum TRAC_j}{\sum TAC_j} \quad (11)$$

where

SCR_i = ratio of applicants retained to applicants available

$TRAC_j$ = total requirement for applicants in group j

TAC_j = total number of applicants in group j .

The summations are taken over all groups (j) with AFQT scores equal to or higher than i .

Thus far, it has been assumed that the constraints ($SCR_i \leq 1$) in each of the categories are likely to be binding. For category IV, the opposite assumption is made, namely, that more recruits in category IV are "free." Equation 12 begins the incorporation of this assumption into the model by defining a variable ($NTAC_4$) for accessions in category IV as what is needed to meet the aggregate accession target (ACCSS).

$$NTAC_4 = ACCSS - TAC_1 - TAC_2 - TAC_{3A} - TAC_{3B} \quad (12)$$

These accessions divided by sel_4 are the category IV applicants needed to fill the aggregate accession target. The actual number of category IV applicants is the larger of two numbers, the number of applicants needed, and the number of category IV applicants that are yielded by the number of recruiters (TAP_4).

$$NTAP_4 = \max (NTAC_4/sel_4, TAP_4) . \quad (13)$$

A final equation is purely for accounting. It states that the total number of recruiters ($RTOT$) is equal to the number needed for prospecting (R) and the number needed for processing.

$$RTOT = R + p(TAP) , \quad (14)$$

where p is recruiter time necessary to process one applicant, and TAP is the total number of applicants in all categories.

Table 3 summarizes the equations and variables of the model. The model minimizes the number of recruiters, subject to these constraints and as long as SCR_i is less than or equal to 1.

Table 3. The model

-
- (1) $AP_s = sCA_s$
 - (2) $AP_w = (1 - s)CA_w$
 - (3) $AP_i = a_{si}AP_s + a_{wi}AP_w$
 - (4) $TAPV_i = AP_i(RE_i)(1 - w_i)$
 - (5) $TAPW_i = TAP_{0i}(w_i)$
 - (6) $TAP_i = TAPV_i + TAPW_i$ $i = I, II, IIIA, IIIB, IVA$
 - (7) $TAC_i = sel_i(TAP_i)$
 - (8) $TRAC_i = f_i(ACCSS)$
 - (9) $Rel = R/R_0$
 - (10) $RE_i = R_0(Rel)^{\alpha_i}$
 - (11) $SCR_i = \frac{\sum TRAC_i}{\sum TAC_i}$, where sums are over all categories equal to or of more capable AFQT.
 - (12) $NTAC_4 = ACCSS - TAC_1 - TAC_2 - TAC_{3A} - TAC_{3B}$
 - (13) $NTAP_4 = \max(NTAC_4/sel_4, TAP_4)$
 - (14) $RTOT = R + \rho(TAP)$
- Min R subject to all these equations and $SCR_i \leq 1$
-

- AC_i = Accessions per recruiter in AFQT group i .
 $ACCSS$ = Required endstrength measured as number of required accessions.
 AP_i = Applicants per recruiter (from both markets) that fall into AFQT group i .
 AP_s = Applicants per recruiter from the school market.
 AP_w = Applicants per recruiter from the work-force market.
 a_{si} = Fraction of applicants in the school market that fall into AFQT category i .
 a_{wi} = Fraction of applicants in the work-force market that fall into AFQT category i .
 CA_s = Applicants per recruiter if the recruiter prospected full time in the school market.
 CA_w = Applicants per recruiter if the recruiter prospected full time in the work-force market.
 f_i = Fraction of required accessions that fall into AFQT group i .
 $NTAC_4$ = Category IV accessions needed to meet aggregate target ACCSS.
 $NTAP_4$ = Number of applicants that fall into AFQT category IV.
 ρ = Recruiter time necessary to process one applicant.
 R = Number of recruiters in prospecting.
 R_i = Number of recruiters devoted to prospecting.
 RE_i = Effective recruiters for group i .
 Rel = Number of recruiters in prospecting, relative to base.
 $RTOT$ = Total recruiters, prospecting plus processing.
 s = Fraction of prospecting time the recruiter spends in the school market.
 sel_i = Ratio of accessions to applicants in AFQT group i .
 TAC_i = Total accessions in AFQT group i .
 TAP_i = Total number of applicants that fall into AFQT category i .
 $TRAC_i$ = Total required accessions in AFQT group i .
 w_i = Fraction of applicants in category i that are walk-ins.
-

PARAMETERS

To apply the model, values must be assigned to the parameters. Table 4 lists the parameter values used for the results in this paper. For cases in which a parameter seemed particularly important in determining a result, but exact information on the parameter was weak, a range of values was used. Nevertheless, the parameter values still are inexact. One purpose of the paper is to suggest directions for future research to improve data in particular areas.

Table 4. Parameter values

Parameter	Value	Units	Source
CA_s	32.5	Applicants per recruiter	Derived from base-case assumptions — ACCSS as below
CA_w	39.0	Applicants per recruiter	— 15,000 recruiters — 60 percent of time prospecting — 50/50 in school market/work-force market — 3.6 low-quality applicants sacrificed for each high-quality applicant (I through IIIA).
a_{sr}	a		
a_j	a		
w_j	.25 ^b	Walk-ins per applicant	Approximation based on Youth Attitude Tracking Study II published by the Defense Manpower Data Center
sel_i	a		
ACCSS	215,000	Required accessions	1987 accessions (categories I through IVA) (see table 5).
R_0	9,000	Base number of recruiters devoted to prospecting	60 percent of roughly 15,000 total recruiters in 1987. The 60 percent is from discussions with staff at the recruiting command. The 15,000 is from the Office of the Assistant Secretary of Defense. (FM&P-AP)

a. See tables 6 through 9.
b. Same for all categories.

Values used for ACCSS and sel_i are calculated from data tabulated for CNA by the Defense Manpower Data Center (DMDC) on the number of male HSDG applicants and accessions by AFQT category for all of DOD (table 5). These data cover FY 1980 through FY 1987. Table 6 presents the FY 1987 data used to produce the accession-to-applicant ratios, sel_i .

Table 5. DOD accessions, applicants, and population
of male high school graduates by AFQT category

AFQT category	Fiscal year							
	1980 ^a	1981	1982	1983	1984	1985	1986	1987
Accessions^{b,c}								
I	12,606	7,428	7,526	8,642	9,534	11,001	9,518	10,911
II	45,844	65,825	71,301	78,181	84,588	70,753	77,249	77,567
IIIA	31,970	39,010	40,272	45,881	51,197	44,227	49,760	50,569
IIIB	38,015	46,996	50,348	55,012	61,592	68,901	78,714	65,477
IVA	23,852	26,019	22,720	17,475	18,085	17,014	12,004	10,317
IVB/C	26,041	14,699	7,973	2,737	245	163	37	32
Applicants^{b,c}								
I	25,571	13,302	16,432	17,124	14,195	13,570	16,049	17,370
II	87,498	118,938	139,081	142,035	114,347	105,328	115,379	114,790
IIIA	57,827	63,834	73,381	76,345	62,041	61,174	65,745	66,574
IIIB	66,298	78,247	89,134	88,715	77,799	91,671	88,658	87,679
IVA	40,832	49,025	49,751	42,124	37,927	37,429	32,282	32,341
IVB/C	51,519	56,225	48,922	35,697	32,892	26,926	21,621	21,304
V	18,807	20,766	12,834	6,938	6,199	7,276	5,248	4,772
1980 reference population, ages 17-21								
I	605,562							
II	2,032,861							
IIIA	890,358							
IIIB	1,084,089							
IVA	411,335							
IVB/C	459,076							
V	259,405							

a. Correctly normed scores.

b. Includes individuals who were high school seniors at the time of application.

c. ASVAB scores prior to FY 1985 are expressed in terms of the 1944 reference population. Scores from FY 1985 and later are expressed in terms of the 1980 reference population. The differences are minor and are ignored in this analysis.

Table 6. Parameter values for the processing stage: accession-to-applicant ratio^a by AFQT category

AFQT category	sel_i
I	.63
II	.67
IIIA	.76
IIIB	.75
IVA	.48
IVBC	.00
V	.00

a. Calculated from FY 1987 data on applicants and accessions in table 5.

Quality of Applicants From the School and Work-Force Markets

An important set of parameters describe the quality of each market. These parameters (a_{si} and a_{wi}) are equal to the fractions of the applicants in the school and work-force markets that fall into each mental category—I, II, IIIA, IIIB, and IV. Appendix A presents some recent data concerning these fractions, but they are inconclusive. As a result, two limiting cases of the parameters are developed for use in the simulations.

The five test-score-category shares in two markets make up ten unknown quality parameters. These ten parameters shown in table 7, however, are subject to several equations restricting the allowable values. Column 2 describes the 1987 mix of applicant mental categories in all of DOD. The ten parameters in columns (1) and (3) must average to column (2) when weighted by relative number of applicants from each market, $a_w/(a_w + a_s)$ and $a_s/(a_w + a_s)$. (Assumptions regarding these numbers are described below.) The requirement that columns (1) and (3) average to column (2) specifies five equations for the ten unknown parameters. In addition, column (1) must sum to 1, a sixth equation. No further equations are necessary to ensure that column (3) sums to 1, as this is guaranteed by the six equations specified already.

Table 7. School and work-market parameters by AFQT category

AFQT Category	Work (1)	Average (2)	School (3)
I	a_{w1}	.055	a_{s1}
II	a_{w2}	.360	a_{s2}
IIIA	a_{w3a}	.209	a_{s3a}
IIIB	a_{w3b}	.275	a_{s3b}
IV	a_{w4}	.101	a_{s4}
Total	1.00	1.00	1.00

The six equations ensure only that the school and work-market parameters (a_{w1} , a_{si}) are consistent with the observed 1987 distribution of applicants. There remains a range of feasible parameter values, consistent with the six equations. Without definitive data, the analysis uses a range of values for the unknown parameters, which results in a range of cost estimates.

The Range of Quality Parameters

The range of parameters is generated by varying assumptions about:

- How different the two markets are
- How important the diminishing returns are to added recruiters.

The parameters in table 8 illustrate contrasting assumptions about the differences between the two markets. The table fills in specific values for the unknown parameter values that were shown in table 7 and also provides values for a_s and a_w , the numbers of recruits obtained per effective recruiter year spent on prospecting in each market.

Table 8. Parameter values for the prospecting stage

	Same markets			Different markets		
	Work (1)	Average (2)	School (3)	Work (1)	Average (2)	School (3)
Applicants per recruiter	35.75	35.75	35.75	39.00	37.50	32.50
Shares						
I	.055	.055	.055	.037	.055	.077
II	.360	.360	.360	.240	.360	.504
IIIA	.209	.209	.209	.251	.209	.158
IIIB	.275	.275	.275	.343	.275	.193
IV	.101	.101	.101	.129	.101	.067
Total	1.000	1.000	1.000	1.000	1.000	1.000

The parameter values shown on the left side of table 8 represent the assumption that the two markets are identical. The parameter values shown on the right side of the table represent one example of the opposite assumption: that the markets are quite different—indeed, more different than is apparent in the tabulations in appendix A. These parameters, representing different markets, have the following characteristics:

- The share of categories I and II applicants from the work-force market is a third below average.
- The share of category IV applicants from the work-force market is a third above average.
- For the school market, the ratio of category IIIA to category IIIB applicants is 0.82, as in the 1980 reference population (see table 5).
- The parameters a_s and a_w are determined so that 3.61 low-quality applicants (IIIB and IV) must be sacrificed to obtain one more high-quality applicant (I, II, and IIIA). The value 3.61 is roughly consistent with empirical findings in reference [1].

Appendix B provides further details on these parameters.

The final parameters needed for the model concern the diminishing returns as extra recruiters are added. Constant returns would imply that increasing the number of recruiters by 1 percent also increases the number of applicants by 1 percent. (This assumption is equivalent to the assumption that the supply of applicants is unit elastic with respect to the number of recruiters.) The assumption of constant returns, however, is not consistent with discussions with recruiters or a number of empirical studies. Thus, the analysis builds in diminishing returns to extra recruiters. Diminishing returns are specified as applying to each AFQT category separately. For instance, increasing the number of recruiters by 1 percent might bring in 0.5 percent more applicants in the category IIIA (elasticity of applicants with respect to recruiters equals 0.5), but only 0.3 percent more in category I (elasticity of applicants with respect to recruiters equals 0.3).

Two sets of elasticities representing diminishing returns were used, both of which were derived by the study team using estimates by Cralley (reference [8]). For details, see appendix C. Table 9 presents the elasticities.

Table 9. Elasticities of applicants with respect to recruiters

AFQT category (1)	Elasticity (low) for I-III = .49		Elasticity (high) for I-III = .75	
	Cumulative (2)	Individual (3)	Cumulative (4)	Individual (5)
I	.19	.19	.29	.29
II	.36	.36	.55	.59
IIIA	.49	.72	.75	1.10
IIIB	.58	.77	.89	1.18
IV	.63	1.62	.96	2.34

RESULTS

The contrasting assumptions of same and different markets and of low and high elasticities define four sets of parameters:

- Same market, low elasticities
- Same market, high elasticities
- Different markets, low elasticities
- Different markets, high elasticities.

The model is run with each of these four sets of parameters to provide an indication of sensitivity to differing assumptions.

Given the parameter values and historical accession rates, the model proceeds by computing the number of recruiters and percentage of prospecting time in the school market required to obtain a specified number and quality of enlistments. The percentage in the school market is allowed to vary between 40 and 60 percent, an allowable range of variation developed after discussions with recruiting staff officers. Each solution is consistent with the equations in table 3. The screening parameters (SCR_i) under each set of parameters are varied until the quality requirements for the accession cohort are satisfied. If any screening parameter exceeds 1, the split of time between the school and work-force markets is changed or the number of recruiters is increased. A solution is reached when all screening parameters fall below 1.

Table 10 and figure 6 present the model's calculation of the relative numbers of recruiters required to achieve cohorts with specified AFQT mixes. Absolute numbers of recruiters are in parentheses. One of the mixes is called base case because it is similar to the actual mix in 1987.

Table 10. Recruiters required to achieve alternative AFQT distributions

Distribution by AFQT category (fraction)						Relative number of recruiters (absolute number in parentheses)			
						High elasticities		Low elasticities	
						Different markets	Same market	Different markets	Same market
I-III A	I	II	III A	III B	IV A				
.75	.05	.40	.30	.25	.00	1.24 (18,500)	1.26 (18,800)	1.34 (20,000)	1.36 (20,500)
.70	.05	.38	.27	.25	.05	1.11 (16,600)	1.13 (17,000)	1.16 (17,300)	1.18 (17,700)
.65 (base)	.05	.36	.24	.30	.05	1.00 (14,900)	1.00 (15,000)	1.00 (14,900)	1.00 (15,002)
.60	.04	.34	.22	.30	.10	.92 (13,700)	.92 (13,800)	.89 (13,300)	.89 (13,400)
.55	.04	.31	.20	.30	.15	.86 (13,000)	.87 (13,100)	.82 (12,300)	.83 (12,400)

Figure 6 here

RECRUITERS AND OTHER RESOURCE COSTS

The number of recruiters is used as a measure of recruiting resources for two reasons. First, recruiters are the most important resource in recruiting, and second, the other resources are designed to assist recruiters either directly or indirectly in achieving their objectives. Table 11 shows the distribution of recruiting resources for FY 1987. With the exception of the college fund "kickers" and enlistment bonuses, the resources are not targeted to high AFQT category recruits. (The college fund kickers are contributory programs providing educational benefits beyond the Montgomery G.I. Bill. They can provide participants up to \$25,000 in college assistance when added to the basic G.I. Bill.) Because enlistment bonuses are much more effective at channeling high-AFQT recruits into appropriate skills than at expanding the market for high AFQT enlistments, the only significant market expansion resource for such recruits is the college fund "kickers." Thus, between 90 and 95 percent of DOD recruiting resources are expended on the general recruit population. (It may well be that substantial expansion of enlistment programs targeted to higher AFQT recruits would be more cost effective than the scaling of resources analyzed here. Available information on additional recruiting costs of such programs is limited by the extent and variability of recent programs.)

Table 11. Distribution of DOD active-force recruiting resources for FY 1987 (in millions of dollars)

Resource category	Expenditure	Percent
Military pay	669.1	47.9
Civilian pay	57.5	4.1
Recruiting support	197.7	14.1
Leased facilities	83.7	6.0
Communications	55.9	4.0
Advertising	150.6	10.8
College fund "kickers"	89.6	6.4
Enlistment bonus	87.8	6.3
Training	6.1	.4
Total	1,397.9	100.0

SOURCE: OASD(FM&P)(AP), Apr 1988.

As a first approximation, then, the costs of improving the AFQT mix is assumed to be proportional to the number of recruiters. It is assumed that all recruiter support and advertising expenditures increase proportionally with the number of recruiters.

Estimates of required dollar resources are obtained by multiplying the total resources (\$1.4 billion) from table 11 by the relative number of recruiters in tables 9 and 10. The results are shown in table 12.

Table 12. Estimated recruiting cost of alternative AFQT distributions

Fraction I-III A	Distribution by AFQT category (fraction)					Cost (billions of dollars)			
	I	II	III A	III B	IV A	High elasticities		Low elasticities	
						Different markets	Same market	Different markets	Same market
.75	.05	.40	.30	.25	.00	\$1.7	\$1.8	\$1.9	\$1.9
.70	.05	.38	.27	.25	.05	1.5	1.6	1.6	1.6
.65	.05	.36	.24	.30	.05	1.4	1.4	1.4	1.4
.60	.04	.34	.22	.30	.10	1.3	1.3	1.2	1.2
.55	.04	.31	.20	.30	.15	1.2	1.2	1.1	1.2

Figure 7 suggests that lowering AFQT score requirements so that 55 percent would be in categories I-III A would lower recruiting costs to between 82 and 88 percent of base level. Requiring higher AFQT scores (75 percent in categories I-III A) would increase recruiting costs by between 24 and 36 percent of base costs.

Figure 7 here

In comparing the four lines, it is clear that the model is not sensitive to whether or not the two markets are assumed to yield different ratios of high-aptitude prospects. This insensitivity is fortunate because there seems to be little firm evidence on the extent to which the markets differ.

By contrast, the difference attributable to different assumptions about the elasticities is substantial. It is unclear to what extent this uncertainty can be reduced, since it exists despite a massive body of empirical research.

CONCLUSIONS

The purpose of this paper is to answer a longstanding question: What is the cost of altering the aptitude distribution of military enlistments? The question is answered by means of a model focused on the idea of jointness in production, i.e., a case in which it is not possible to allocate recruiting costs to individual aptitude categories.

The method can provide a range of relative costs for any specified distribution of accessions by AFQT category. Results are shown for five such distributions, including the approximate FY 1987 distribution. In addition to the other potential uses mentioned in the introduction, the method could be extended to search over a variety of distributions to provide estimates of which ones are feasible without large increases in costs.

The parameters and results of this paper apply to DOD as a whole, not to a specific service within DOD. It would be straightforward to apply the model to a specific service, and follow-on research at CNA is examining an application to the Marine Corps.

Where possible, the parameter values used to implement the model were guided by the existing empirical literature. Nevertheless, for some of the parameters, little empirical evidence is available. This uncertainty was resolved by using a range of parameter values that resulted in a range of estimated costs. There are several areas in which better data or further analysis could improve the cost estimates:

- *Determination of plausible limits on the dissimilarity in aptitudes among applicants from the school and work-force markets.* The analysis presented in the appendix is a first step in this direction. Fortunately, uncertainty about dissimilarities in the markets has relatively little effect on the cost estimates. The uncertainty does, however, argue against using the model as a management tool to direct the percentage of time that recruiters should spend in each market.
- *Determination of the elasticity of accessions, by AFQT category, to the number of recruiters (or the effort of individual recruiters).* Reducing this source of uncertainty would be equivalent to finding feasible methods and data to estimate recruit supply models for individual AFQT categories. Empirically, this is the largest source of uncertainty in the present model.
- *Determination of the extent to which AFQT category IVA recruits are "free."*

- *Introduction of the effects of civilian labor market conditions on the supply of recruits in different AFQT categories.* In principle, the model could be expanded to incorporate these effects on recruiting costs by including existing estimates of relative pay and unemployment elasticities, as was done with recruiters. For example, the current upward trend in the returns to college education would be expected to make recruiting high-aptitude individuals relatively more difficult.
- *Addition of a complementary analysis of the costs and feasibility of expanding incentives designed for recruiting subpopulations with different aptitudes.* Some work along these lines has already been done, and is ongoing, for the highly successful Army College Fund. The costs of such programs depend on the career options and opportunities available to high-aptitude individuals.

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NOTES

1. In the mathematical model, the origin is shifted to point W , representing the number of walk-in interviews or applications of high- and low-quality candidates.

APPENDIX A: AFQT DISTRIBUTIONS OF SCHOOL AND WORK-FORCE APPLICANTS FOR ACTIVE DUTY

The alternative scenarios used in the simulation to generate the range of costs of improving recruit quality are distinguished, in part, by the degree of difference in the AFQT distributions of applicants between the school and work-force markets. This appendix presents and interprets data on the aptitude distributions of recruits obtained from the school and work-force markets to help assess the parameter range used in the paper.

The Defense Manpower Data Center (DMDC) provided CNA with data on non-prior-service, first-time applicants for active duty to all services for fiscal years 1987 and 1988. In addition to AFQT scores, the data include the educational status of each individual at the time of application. Tables A-1 and A-2 show the distributions of applicants among high school seniors and those who graduated but did not go on to college for each of the two fiscal years. These distributions do not support the hypothesis that the school and work-place markets are quite different. The different-market case suggests that recruiters have some ability to indirectly target high-aptitude recruits by shifting effort from the work force to the high schools. The same-market case suggests that recruiters cannot target high-aptitude recruits at all by shifting effort from the work force to the high schools. Thus, tables A-1 and A-2 seem to be evidence that the costs of improving recruit quality would be nearer the higher end of the estimated range than the lower end.

Table A-1. Distribution of FY 1987 applicants for active duty by AFQT category and education status

AFQT category	Education status			
	High school seniors (school market)		High school diploma graduates (work-force market)	
	Number	Fraction	Number	Fraction
I	5,765	.031	14,160	.046
II	59,795	.316	95,008	.310
IIIA	42,640	.225	55,713	.182
IIIB	55,269	.292	81,271	.265
IV	24,378	.129	56,314	.183
V	1,320	.007	4,440	.014
Total	189,167	100.0	306,904	100.0

NOTE: The work-force market does not include those with educational credentials beyond high school. These are discussed below.

**Table A-2. Distribution of FY 1988 applicants for active duty
by AFQT category and education status**

AFQT category	Education status			
	High school seniors (school market)		High school diploma graduates (work-force market)	
	Number	Fraction	Number	Fraction
I	4,988	.030	9,098	.042
II	51,122	.311	63,323	.297
IIIA	37,255	.226	38,436	.180
IIIB	48,320	.293	57,040	.267
IV	21,730	.132	41,993	.197
V	1,336	.008	3,610	.017
Total	164,751	1.000	213,500	1.000

NOTE: The work-force market does not include those with educational credentials beyond high school. These are discussed below.

Even though the data in these tables are the best data available for judging the similarity of the two markets, there are several reasons why they may understate the degree to which high-aptitude recruits can be targeted by shifting effort to the school market:

- Measured aptitude increases with age, whether or not the individual is in service. Individuals recruited beyond high school will tend to score higher on the AFQT than they would have if recruited in high school.
- The work-force market contains substantial numbers of non-graduates who are screened out by this selection criterion. The school market consists only of high school seniors who are expected to graduate. The school market thus allows recruiters to target individuals with the credential (high school diploma) that is the best single predictor of success in the service. More to the point, nongraduates tend to have lower scores on the AFQT than high school seniors or graduates (see table A-3).

- The richest market segment in terms of measured vocational aptitude is the population with an educational credential beyond high school. Table A-3 shows FY 1987 and FY 1988 aptitude distributions for applicants with these credentials. To target this high-aptitude population, recruiters need to locate college-bound individuals, or those already enrolled in college. High school seniors provide an excellent opportunity for recruiters, because they are at a natural decision point regarding post-secondary training and employment. The Army College Fund is designed to appeal to this segment of the school market.

Table A-3. Distribution of applicants for active duty by fiscal year, AFQT category, and education status

AFQT category	No high school credential		General high school equivalency		Other post-secondary credential	
	Number	Fraction	Number	Fraction	Number	Fraction
FY 1987 educational status						
I	375	.010	329	.018	3,339	.160
II	7,112	.187	4,650	.255	9,239	.436
IIIA	8,408	.221	4,812	.264	3,103	.146
IIIB	12,586	.332	5,660	.311	3,605	.170
IV	8,747	.230	2,615	.144	1,741	.082
V	732	.19	151	.008	121	.006
Total	37,960	1.000	18,217	1.000	21,208	1.000
FY 1988 educational status						
I	182	.012	343	.016	2,439	.146
II	2,972	.204	5,145	.243	7,042	.422
IIIA	3,224	.221	5,692	.269	2,511	.150
IIIB	4,771	.326	6,724	.318	3,071	.184
IV	3,198	.219	3,043	.144	1,539	.092
V	268	.018	206	.010	104	.006
Total	14,615	100.0	21,153	100.0	18,706	100.0

The combination of an expanded enlistment incentive like the Army College Fund and redirection of recruiter effort from the work force market to the school market is likely to be more cost effective for recruiting high-aptitude recruits than simply shifting recruiter effort.

Data on initial interviews with prospective recruits, rather than applicants, would better address aptitude differences between the markets among those interested in service. It is important to be able to track information on initial recruiter contact because recruit prospecting in the schools this year is likely to yield applicants in future years. Work-force applicants may result from school prospecting, but the extent of the spillover is not known, and the spillover may differ by quality category. Furthermore, spillover is not symmetric because the flow of individuals is from high school to the work force, not vice versa.

It is difficult to pinpoint the degree to which recruiters can successfully target high-aptitude recruits by shifting prospecting effort between the school and work-force markets. Data on applicants for active duty for all of the services indicate that the two markets are more similar than assumed in the parameters of the optimistic case. However, these applicant data are likely to underestimate the degree to which recruiters can target high-aptitude recruits in the school market.

APPENDIX B: PARAMETERS USED TO REPRESENT DIFFERENT MARKETS

Dissimilarities between the two markets in their AFQT scores are represented by assuming that the school market tends to yield applicants with higher AFQT scores than the work-place market. (The opposite assumption would yield the same costs; it is the degree of dissimilarity that matters, not the direction.)

The first specific assumption used in specifying parameter values is that the fractions of category I and category II individuals in the work-place market are low relative to the average. This assumption is based on discussions with a recruiting official who indicated that high-quality applicants are relatively rare in the work market. To assign a specific value to the parameters, it was assumed that they were each one-third below the average.

The shares in the school market were then derived by requiring that the shares in the two markets average to the observed share for both markets combined. The average uses weights that sum to 1 and are proportional to a_s and a_w , the numbers of applicants per recruiter prospecting year in each market. These weights are derived as described later in this appendix.

Just as the work-place market has shares below average in categories I and II, it was assumed that the school market had a share below average in the lowest-quality category, IV. This share is set at one-third below the observed average.

The study team considers the assumptions so far as representing a limiting case of difference between markets; they represent greater differences among markets than the study team has been able to find in tabulations of historical applicant data (see appendix A).

The next assumption is that the ratio of applicants in category IIIA to applicants in category IIIB for the school market is the same as that for the 1980 reference population, 0.82. This assumption is meant to recognize that category IIIA is somewhat smaller than IIIB.

The assumptions so far are sufficient to derive the shares in each market once the weights (proportional to a_s and a_w) are derived. The following section describes how empirical results are used to derive these weights.

The Number of Applicants in Each Market

Since the school market is assumed to produce applicants with higher AFQT scores, the question arises as to why the recruiters do not focus completely on the school market. (Complete specialization by process is a common characteristic of linear process models. This same question would arise if the opposite assumption about quality in the different markets were made. Diversification may arise, for several reasons, including seasonality in the school market and targeting of individuals primarily on the basis of educational credentials.) To balance out the higher AFQT scores in the school market, recruiter time spent in the work-place market must yield a higher quantity of applicants.

To determine how much higher the quantity of applicants is in the work-place market, use is made of previous empirical work. Though empirical work cannot provide guidance on individual parameters, it can place restrictions on aggregates of parameters. One such restriction concerns the tradeoff between high- and low-quality high school diploma graduates. Counting categories I-III A as the high-quality categories, [1] estimates that about three to four low-quality (category IIIB and IV) accessions must be sacrificed to divert effort sufficient to obtain one high-quality accession.

This estimate of the tradeoff is used to place an additional restriction on the parameters of the school and work-force prospecting processes. Begin with an expression for the increase in high-quality accessions (dh) that results from shifting recruiter effort toward the school market by ds .

$$dh = (ac_{sh}a_s - ac_{wh}a_w) ds \quad , \quad (B-1)$$

where

$$ac_{sh} = a_{s1}sel_1 + a_{s2}sel_2 + a_{s3a}sel_{3a}$$

$$ac_{wh} = a_{w1}sel_1 + a_{w2}sel_2 + a_{w3a}sel_{3a} \quad .$$

The first term in the expression for dh is the number of additional high-quality (AFQT category I-III A) accessions resulting from a shift of effort to the school market. The individual terms in ac_{sh} represent the shares of accessions that fall in each particular category. The second term in the expression for dh is the loss of high-quality accessions from the work-place market due to the shift of effort to the school market. The difference between the two terms is the net gain in high-quality accessions associated with the shift.

The corresponding decrease in low-quality accessions is:

$$dl = (ac_{s1}a_s - ac_{w1}a_w)ds \quad , \quad (B-2)$$

where

$$ac_{s1} = a_{s3b}sel_{3b} + a_{s4}sel_4$$

$$ac_{w1} = a_{w3b}sel_{3b} + a_{w4}sel_4 \quad .$$

The terms in this expression are analogous to those above, but apply to AFQT categories IIIB and IV.

The number of low-quality accessions sacrificed to obtain one high-quality accession is:

$$-dl/dh = -(ac_{s1}NR - ac_{w1})/(ac_{sh}NR - ac_{wh}) \quad , \quad (B-3)$$

where

$$NR = a_s/a_w \quad .$$

Requiring that $-dl/dh$ take a value between 3 and 4 places a restriction on NR , which describes the relative yields of the two markets. If a_s is set at 32.5 and a_w at 39, then $-dl/dh = 3.61$. (The restriction is very tight; small deviations in the ratio of a_w to a_s changes $-dl/dh$ sharply. Increasing a_w increases the loss of low-quality recruits and decreases the gain of high-quality recruits associated with shifting effort to the school market. Both effects tend to increase the value of the ratio $-dl/dh$.) Although the absolute values of a_s and a_w appear arbitrary, they are roughly consistent with interviews with recruiters. Further, other values of a_s and a_w maintaining the same ratio generate the same relative costs of various AFQT distributions.

With these parameters calibrated to earlier empirical results, all existing empirical information on recruit quality tradeoffs has been built into the analysis. The resulting parameters are shown in table 8 of the main text (right side).

APPENDIX C: INTERPOLATION OF ELASTICITIES

Cralley makes cross-section estimates of elasticities for three groups: categories I-II, I-III A, and I-IV. (All elasticities reported are based on accessions, not applicants. It is assumed that the elasticity of applicants with respect to recruiters is the same as the elasticity of accessions with respect to recruiters. To obtain 10 percent more accessions, recruiters must obtain 10 percent more applicants.) These elasticities were interpolated to generate more detailed elasticity estimates for groups that cumulate different categories (e.g., I-III B) and for the individual categories. Two sets of elasticity estimates were constructed. One, labeled the "low" set, uses Cralley's result that the cumulative elasticity of group I-III A is 0.49. The alternative "high" set is based on the assumption that this elasticity is 0.75. From these three elasticities, two more were interpolated for categories I and I-III B. To allow interpolation, the categories were renumbered from $x = 1$ (for category I-IV) to $x = 5$ (for category I). A quadratic expressing elasticity as a function of x was fit and used to interpolate the missing categories. There were three points, so the quadratic was chosen to pass through all three points.

The resulting estimates were assumed to be unchanging over time, and were combined with 1987 data on accessions (table 5 of the main text) to convert from elasticities for combined groups (such as category I-III A) to elasticities that can be applied to individual categories. The conversion to individual categories starts by noting that (to an approximation) the elasticities for combined groups (such as category I-III A) are weighted averages of those for the individual groups. The weights are the shares of each category in accessions (because the elasticity estimates pertain to accessions rather than applicants). For example, the elasticity for category I-II is a weighted average of the elasticity for category I and the elasticity for category II. Similarly, the elasticity for category I-III A is a weighted average of elasticities for category III A and for category I-II. In this latter example, since the weights are known, along with the elasticities for category I-III A and for category I-II, the remaining elasticity, for category III A, can be solved for. The resulting elasticities are presented in table 9 of the main text.

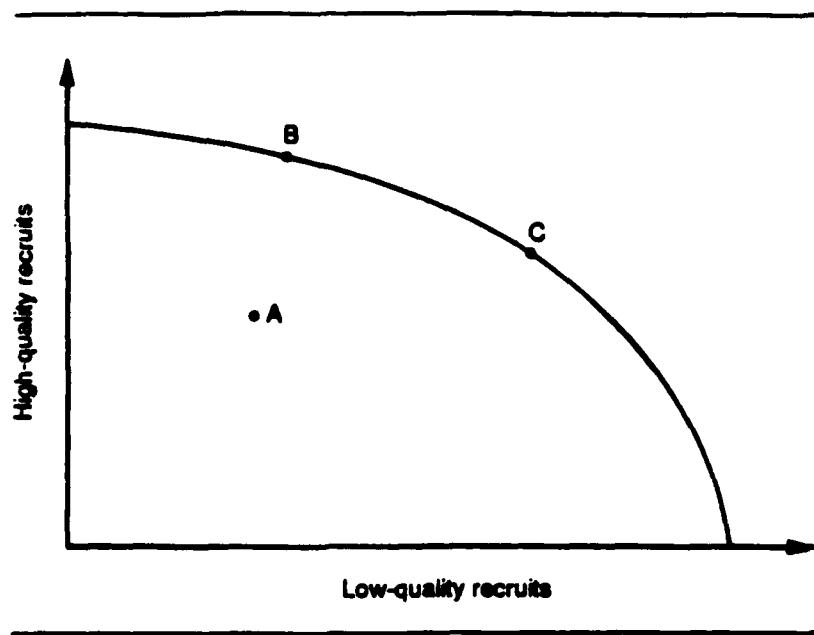


Figure 1. Production tradeoff curve

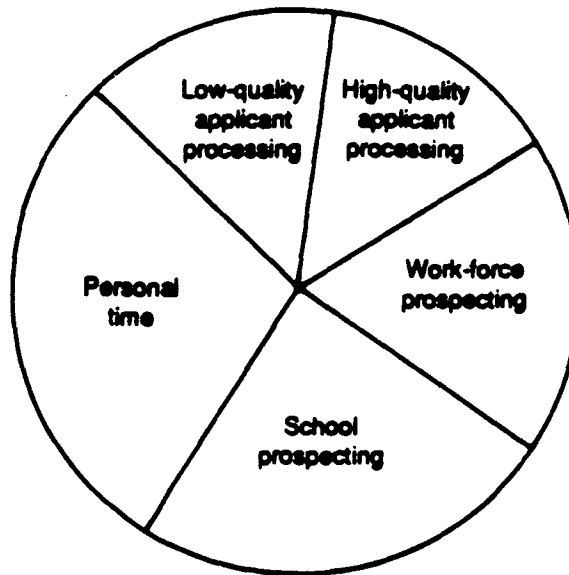


Figure 2. Recruiter time allocation

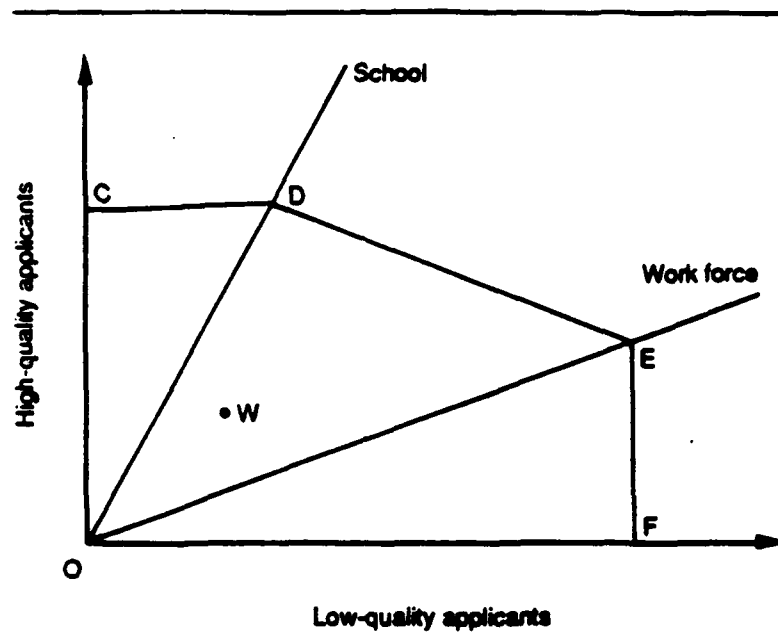


Figure 3. Stage I: recruit prospecting

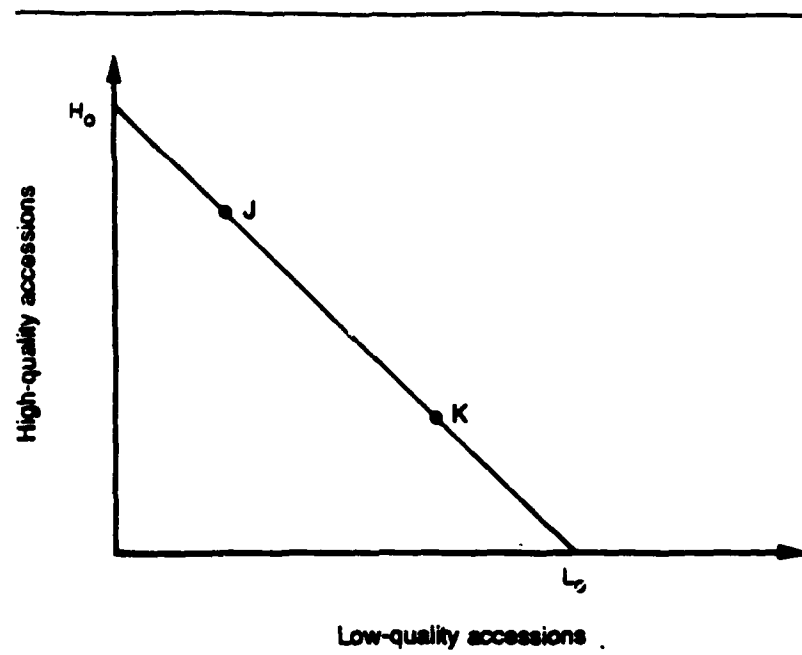


Figure 4. Stage II: recruit processing

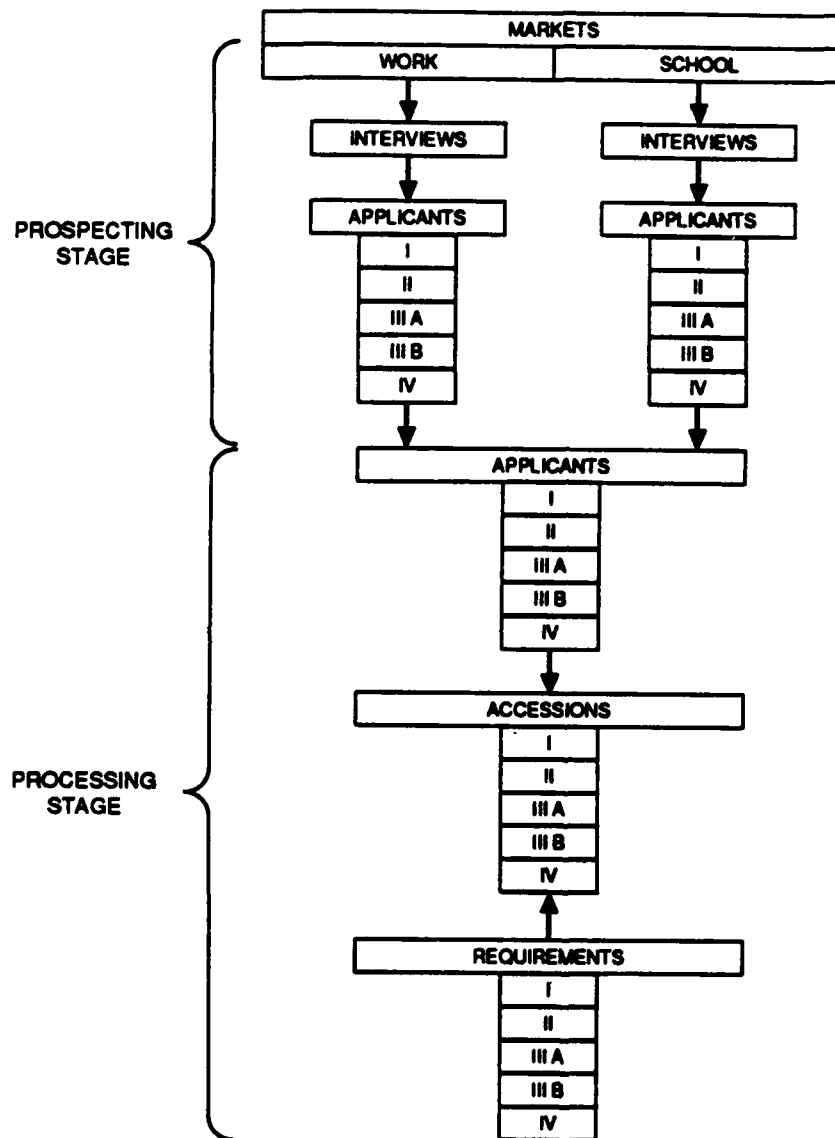


Figure 5. The two-stage/multi-process model

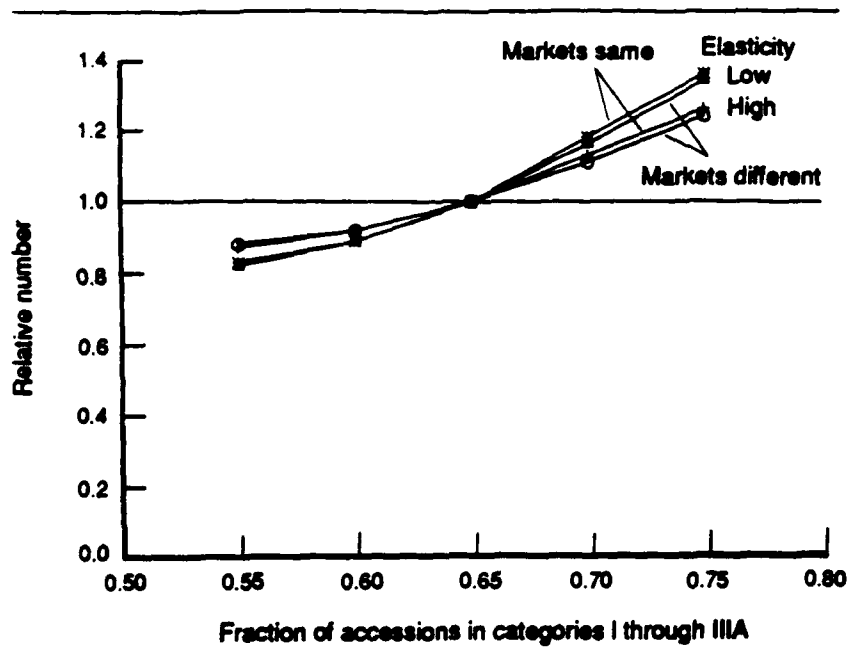


Figure 6. Relative numbers of recruiters required to achieve alternative AFQT distributions

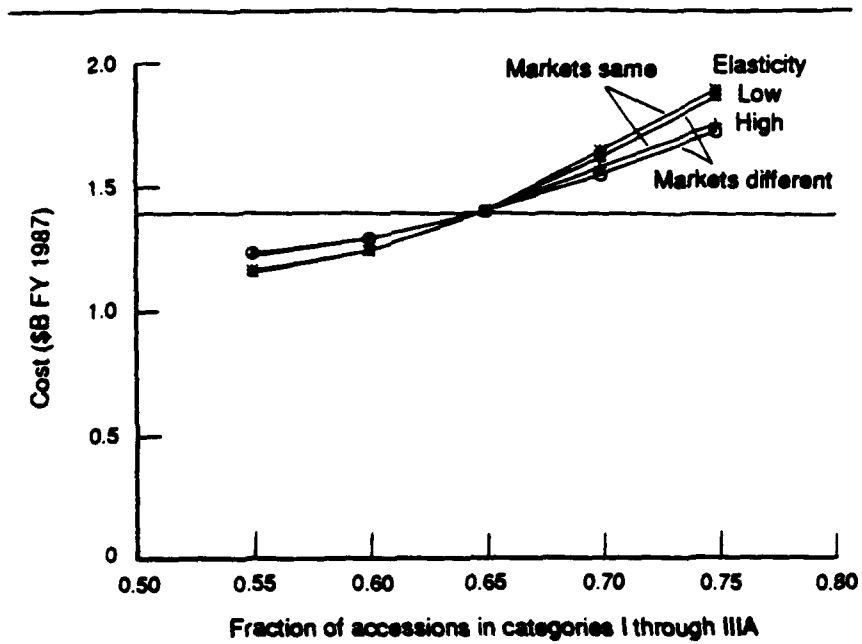


Figure 7. Cost of alternative AFQT distributions

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